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SOIL MOISTURE SENSOR

[Bodenfeuchtesensor]

Not named

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SOIL MOISTURE SENSOR

A soil moisture sensor has at least two electrodes (2a, 2b) that can be inserted into the soil as well as a device (1) for applying an alternate voltage on the electrodes. A device for forming an output signal that is dependent from the electric capacity (C) is provided between the electrodes (2a, 2b). It is provided in accordance with the invention, that the electronic components of the soil moisture sensor are arranged on a printed circuit board (7) and the electrodes (2a, 2b) are configured as printed conductors preferably on the same printed circuit board (7). /2

The invention concerns a soil moisture sensor (called sensor for short in the following) having:

- at least two electrodes (2a, 2b) that can be inserted into the soil,
- a device (1) for applying an alternate voltage on the electrodes, and
- a device for forming an output signal dependent from the capacity (C) between the electrodes (2a, 2b).

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[1] Numbers in the margin indicate pagination in the foreign text.

Such sensors are known, for example, from United States patent 5,424,649 A, French patent 2598810 A1, and United States patent 4,259,632 A.

To create an economic and constructively more simple sensor, a sensor is provided in accordance with the invention, which is characterized in that the electronic components of the soil moisture sensor are arranged on a printed circuit board and the electrodes are configured as printed conductors preferably on the same printed circuit board.

The sensor is suitable for measuring the soil moisture in the soil as well as in sandy or rocky ground. Its electrode or electrodes is (are) inserted into the soil and, depending on the design, the measuring volume amounts to 15-100 ml. The main advantages of this sensor are the simple and therewith economic design, the low current consumption, and a standard voltage output, which makes possible a simple connection to measuring and control units (possibly for irrigation, sprinklers, et cetera).

The sensor is conceived for uses in which a high accuracy and precision are not of foremost importance. It is conceived as an alternative to cheap sensors such as conductivity blocks (for example, of plaster), but has an essentially better long-term stability.

Because of the high dielectricity constant of the water, the electric capacity between sensor electrodes that are buried or inserted into the soil can be used for measuring the soil moisture. In other sensors are used measuring frequencies of between 30 MHz and 3 GHz, since within this range the dielectricity constant is determined almost exclusively volumetrically by the water content and is independent from the soil type, soil composition (mineral soils, humus), and from the salt content.

In contrast thereto, the sensor of the invention measures the capacity of the operating frequencies between 100 KHz and 5 MHz. At these low frequencies, the dielectricity constants of soils are also strongly influenced by the electric dipoles in the soil matrix and by the surface polarization. However, it has been shown that also these indirect, very complex effects are connected fundamentally to the soil moisture. In this way, the echo curves of the sensor become somewhat dependent from the respective soil type, but the low operating frequency allows a fundamentally more simple construction of the measuring electronics and reduces drastically the current consumption.

Further advantages and details of the invention will be explained based on the following description of the figures.

Fig. 1 shows an electric block circuit diagram. Figs. 2 to 4 show different designs.

A quartz oscillator generates as device 1 for applying an alternate voltage a 2 MHz square wave signal (Fig. 1). This square wave signal is applied via a resistance R on the active electrode 2a, the opposite-lying electrode 2b is connected to ground. The electrode capacity is thus connected in the form of a RC element whose time constant effects a phase distortion of the square wave signal. This phase distortion is converted into a pulse width by comparing the distorted signal via an AND gate 3 (Schmitt trigger inputs) with the oscillator signal having a reversed polarity (phase-delayed by 180°). The pulse width signal of this phase detector is smoothed out via a filter element R_1, C_1, and a scaling and buffer amplifier 4 finally supplies the output signal (Standard 0-1 V).

The oscillator 1 and the phase detector (AND gate 3) are realized with high-speed CMOS gates. The operating voltage is stabilized by a micropower SV controller (types with low longitudinal voltage allow the operation of 6V batteries). As output amplifier serves a type with simple voltage supply, which can be adjusted in the zero position and in the reinforcement of the correcting elements 4a, 4b.

This construction allows operating frequencies between 100 KHz and 5 MHz. With about 2 MHz can be combined a low current absorption (for example, 4 mA) with a short adjusting period (for example, 4 ms) after activation.

In the designs according to Fig. 2 and Fig. 3, the electrodes 2a, 2b are configured as rods. They are encapsulated in an isolating layer 5, so that only capacitive currents can flow (with a 2 MHz operating current would have to be taken into account otherwise also the electrolytic conductivity of the soil, which would require more complex electronics). The sensor rods are installed in a sealed housing 6, in which the electronics are located. The sensors can be configured in different sizes. An improved screening against external electrical influences can be achieved in that only the active measuring electrode 2a is isolated and is arranged between two blank earth electrodes 2b (Fig. 3). This construction has proven to be particularly advantageous if several sensors are to be operated directly side by side. /3

As an option, these sensors can include, in addition, a temperature sensor for simultaneous measurement of the soil temperature.

In the further development in accordance with Fig. 4, the manufacturing expense is reduced considerably by accommodating

the entire sensor, including the electrodes 2a, 2b, on a single printed circuit (printed circuit board 7). The electronics at the upper end of the printed circuit board and the cable connections are potted (for example, in epoxide 8). The electrodes 2a, 2b at the lower end are configured single or double sided on the printed circuit board, the isolation occurs via a mechanically robust coating (for example, metal primer and epoxide). The active measuring electrode 2a is encased by the earth electrode 2b, which can also be left blank in this design to achieve an amplified screen effect. In this case, the surface is passivated via a tinning or guilding. This design can also include an optional temperature sensor.

Patent Claims

1. A soil moisture sensor having

    - at least two electrodes (2a, 2b) that can be inserted into the soil,
    - a device (1) for applying an alternate voltage on the electrodes, and
    - a device for forming an output signal dependent from the capacity (C) between the electrodes (2a, 2b),

    wherein the electronic components of the soil moisture sensor are arranged on a printed circuit board (7) and the

electrodes (2a, 2b) are configured as printed conductors preferably on the same printed circuit board (7).

2. The soil moisture sensor of claim 10, wherein the electronic components are potted in a hardenable mass, for example, epoxy resin.

3. The soil moisture sensor of claim 10 or 11, wherein the printed conductors acting as electrodes (2a, 2b) are at least partially covered and isolated by a coating, for example, a metal primer or epoxy resin.

4. The soil moisture sensor of one of the claims 1 to 3, wherein all the electrodes (2a, 2b) are encapsulated or covered with an isolating layer.

5. The soil moisture sensor of one of the claims 1 to 3, wherein an electrode (2a) is encapsulated or covered with an isolating layer, while the other electrode(s) (2b) configured as earth electrode(s) is (are) blank.

6. The soil moisture sensor of one of the claims 1 to 5, wherein an electrode (2a) encapsulated or covered with an isolating layer (5) is arranged between two earth electrodes (2b).

7. The soil moisture sensor of one of the claims 1 to 6, wherein the device (1) for applying an alternate voltage generates a frequency of between 100 KHz and 5 MHz, preferably about 2 MHz.

8. The soil moisture sensor of one of the claims 1 to 7, wherein the device (1) for applying an alternate voltage generates a square wave voltage.

9. The soil moisture sensor of one of the claims 1 to 8, wherein the electrodes (2a, 2b) form the capacity (C) of a RC element, which is fed at the input by the device (1) for applying an alternate voltage and which delivers at the output side a phase-distorted signal, from which the output signal is obtained, which is dependent from the capacity between the electrodes (2a, 2b).

10. The soil moisture sensor of claim 9 having an AND gate (4) with Schmitt trigger inputs, wherein the phase-distorted signal is applied on the first input via the RC element and wherein a reference signal is applied on the second input, which is phase-delayed by 180° with respect to the alternate voltage applied on the RC element at the input side./4

11. The soil moisture sensor of claim 10, wherein the output signal of the AND gate (4) is smoothed preferably via a filter element, and is amplified if required.

2 sheets of drawing are enclosed

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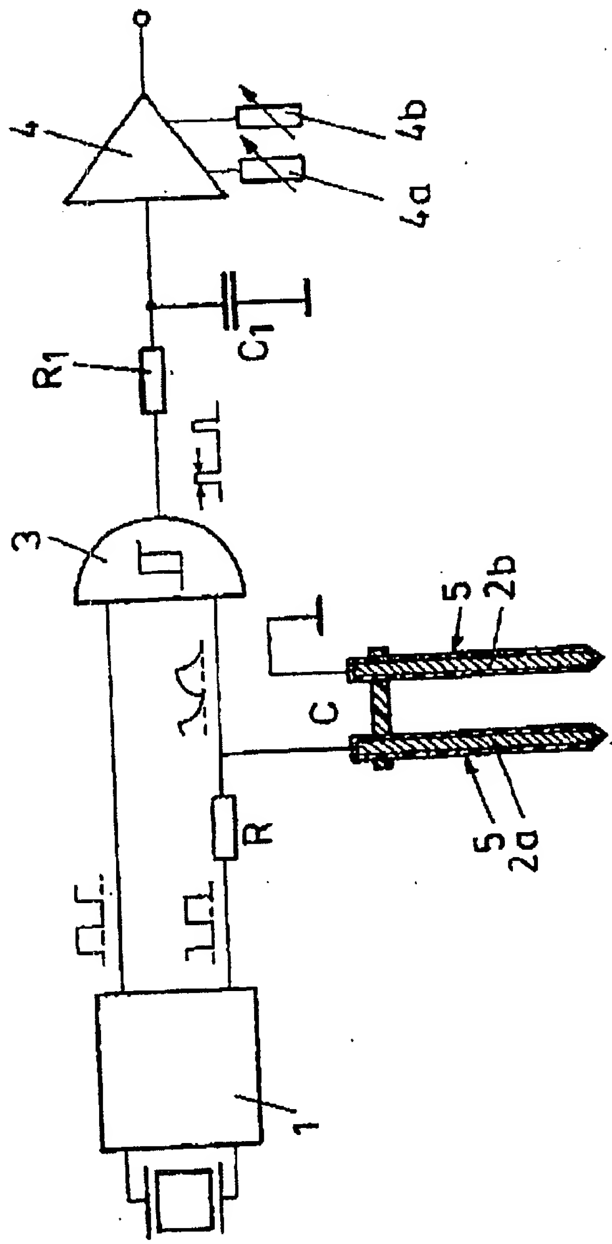

Fig. 1

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Fig.4

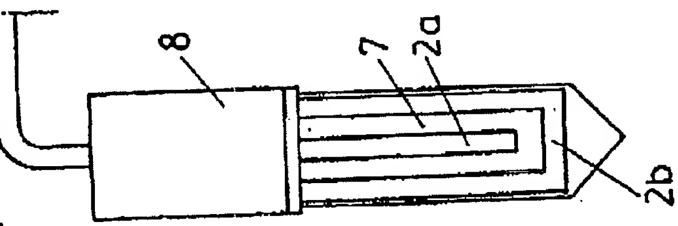

Fig.3

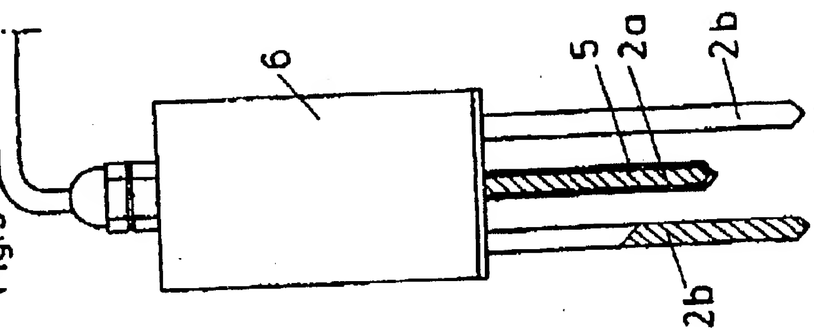

Fig.2